CLAIMS

We claim:

1. A dipole magnet, comprising:

a core; and

a first helically wound coil about the core; and

a second helically wound coil concentrically wrapped about the first coil,

such that the 2 coils form a concentric pair of helically wound coils with coil winding planes of the 2 coils having opposite tilt angles so that the solenoid fields of the coils cancel and the concentric pair of helically wound coils forms a dipole field .

2. The dipole magnet of claim 1, wherein the core is: a coil form.

3. The dipole magnet of claim 1, wherein the core is: a support tube.

4. The dipole magnet of claim 1, wherein the tilt angles of the coil winding planes range from approximately horizontal (at approximately zero degrees) to approximately vertical (near 90 degrees).

5. The dipole magnet of claim 1, wherein the tilt angles of the winding planes of the 2 coils need not be of substantially equal magnitude so long as a combination of tilt angle, current, and conductor size yields solenoid fields of equal strength but opposing directions in the 2 coils.

6. The dipole magnet of claim 1, further comprising:

means for using the dipole magnet as a superconducting accelerator dipole magnet.

7. The dipole magnet of claim 1, further comprising:

means for using the dipole magnet as an MHD (magneto-hydrodynamic) propulsion magnet.

8. The dipole magnet of claim 1, further comprising:

means for using the dipole magnet as a superconducting motor stator.

9. The dipole magnet of claim 1, further comprising:

means for using the dipole magnet as a rotor for an induction motor.

10. The dipole magnet of claim 1, wherein at least one of the first coil and the second coil includes: an elliptical aperture coil configuration.

11. The dipole magnet of claim 1, further comprising:

means for using the dipole magnet with brittle superconducting materials, whereby minimum bend radius of conductors in the first and the second coil windings are large enough to prevent degradation of the superconducting materials.

12. The dipole magnet of claim 1, further comprising:

means for obtaining fields of 10 T and above.

13. The dipole magnet of claim 12, wherein the means for obtaining higher fields includes:

plural layers of concentric pairs of dipole magnets.

14. The dipole magnet of claim 1, wherein the first and the second coils include:

round multi-strand cables.

15. The dipole magnet of claim 1, wherein the first and the second coils include:

round cable-in conduit conductors.

16. The dipole magnet of claim 1, wherein the first and the second coils include:

rectangular cable-in-conduit conductors.

17. The dipole magnet of claim 1, wherein the first and the second coils include:

solid conductors.

18. The dipole magnet of claim 1, wherein the core includes:

helical grooves on a surface layer of the core.

19. The dipole magnet of claim 1, further comprising:

means for counteracting Lorentz forces in the dipole magnet.

20. The dipole magnet of claim 19, wherein the means includes:

wires of high tensile strength material wrapped under tension over the coil.

21. A method of forming a dipole magnet, comprising the steps of:

winding a first layer helical coil about at least one of: a magnet core and a general coil form, wherein the coil wound on the core would have windings at the required final tilt angle, and whereas the coil wound on the general coil form would have a larger aperture and more vertical tilt angle than a final assembled configuration;

transferring the first coil layer from the general coil form to the magnet core and inclining the windings to a selected tilt angle and final position;

winding a second layer helical coil about the first layer or general coil form, wherein the second coil wound over the first layer coil would have windings at a required final tilt angle, whereas the coil wound on the general coil form would have a larger aperture and greater vertical tilt angle than the final assembled configuration;

transferring the second coil layer from the general coil form to the magnet core and inclining the windings to the selected tilt angle and the final position; and

forming electrical connections between the 2 coils so that solenoid fields produced by the 2 coils will be in opposite directions and cancel each other while dipole fields will add.

22. The method of claim 21, further including the step of:

changing dipole strength based on the angle of the tilt of the coil windings, conductor spacing and shape of coil aperture.

23. The method of claim 21, further comprising the step of:

producing a dipole field having systematic field errors of less than approximately $1x10^{-6}$ of the dipole field.

24. The method of claim 21, further comprising the step of:

producing a field of substantially high purity solely from geometry of the tilted windings of the coils without using field adjusting devices.

25. The method of claim 21, further comprising the step of:

producing a field of approximately 10 T and above.

26. The method of claim 25, wherein the step of producing includes the step of:

using multiple layers of concentric pairs of dipoles.

27. The method of claim 21, further comprising the step of:

forming a high packing factor of conductor for efficient field generation without using Rutherford superconducting cables.

28. The method of claim 21, further comprising the step of:

forming a magnet of multipole order n (where n=1 is a dipole) by modulating helical windings with a sine wave of order n, i..e. using a helical advance that is proportional to sin $n\theta$.

29. The method of claim 21, further comprising the step of:

forming a dipole magnet by modulating helical windings with a sine wave of order 1 to form a dipole field.

30. The method of claim 21, further comprising the step of:

forming a quadrupole magnet by modulating helical windings with a sine wave of order 2 to form a quadrupole field.

31. The method of claim 21, further comprising the step of:

forming a sextupole magnet by modulating helical windings with a sine wave of order 3 to form a sextupole field.

32. The method of claim 28, further including the step of:

using the method for at least one of: beam steering and focusing elements, higher order correction magnets in accelerator beam lines and storage rings.

33. The method of claim 29, further including the step of:

using the method for at least one of: beam steering and focusing elements, higher order correction magnets in accelerator beam lines and storage rings.

34. The method of claim 30, further including the step of:

using the method for at least one of: beam steering and focusing elements, higher order correction magnets in accelerator beam lines and storage rings.

35. The method of claim 31, further including the step of:

using the method for at least one of: beam steering and focusing elements, higher order correction magnets in accelerator beam lines and storage rings.

36. The method of claim 21, further comprising the step of:

replacing racetrack shaped coils in magneto-hydrodynamic devices to improve performance and lower costs.

37. The method of claim 21, further comprising the step of:

inserting the dipole magnet coils as stator windings of an electrical machine; and

producing a rotating magnetic field in the aperture of the coils.

38. The method of claim 21, further comprising the step of:

using the dipole magnet coils as the rotor of an electrical machine; and

producing electromotive power.